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ANALYSIS OF FATTY ACID COMPOSITION OF FIVE FRESHWATER FISHES IN CHINA*

by LIU Yufang
(Shanghai Fisheries University)

Key words

Freshwater fish, fatty acid

As a result of new developments in the aquaculture industry in recent years, there has been serious interest in the shift to research on the fatty acid composition of cultured freshwater fish, research which has come gradually out of the achievements of scientists working on the analysis, extraction and use of fatty acids in marine fish. Published data from abroad indicate that much research has been done in the field of fatty acids in freshwater fish by a great number of scientists. However, no study seems to have been made to analyze fatty acid composition in the cyprinids which represent the major category of cultured freshwater fish in China. The author has

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therefore carefully studied five fishes in this family (the grass carp, carp, silver carp, variegated carp and round-headed bream), and analyzed their nutritional value, thus providing the basic data for research on the metabolism of the fatty acids in these five fishes. Such data are useful for improving the culture conditions as well as the production of cultured freshwater fish in regard to both quality and quantity.

Materials and Methods

1. Collection of samples

The samples were collected in fish culture farms in Chuansha and other suburban areas of Shanghai between March and May of 1990. The grass carp and carp weighed over 2 kg each, while the silver carp and variegated carp weighed over 0.8 kg each. The round-headed bream weighed over 0.5 kg each.

2. Extraction of fats

The mature fish were killed, bled and cleaned. Tissues from the parts being tested were obtained and chopped and blended in a mixer. A fixed amount of each sample was weighed out. The fats were extracted using chloroform and methyl alcohol.

3. Conversion to methyl ester

The fat extracted was saponified using a 0.5N sodium hydroxide - methyl alcohol solution. Using boron trifluoride as catalyst, a mixture of fatty acids and methyl ester was obtained for gas chromatographic analysis.

4. Analysis and measurement of fatty acids

A HITACHI Model 663-30 gas chromatograph was used to measure a mixture of fatty acids and methyl alcohol. The standard fatty acid-methyl ester -- U.S. SUPELCO INC PUFA-1. PUFA-2 was used for qualitative analysis. A Model 833 microprocessor was used to determine the composition of the fatty acids (indicated as a % of the total amount of fatty acids) by normalization. The specifications of the gas chromatograph were as follows: chromatographic column: diameter ϕ 2mm x 2m glass packing tube, fixed phase,10% DEGS, 80/100 mesh, chromosorb WAW (Japan, U.S.); detector: hydrogen flame ion detector (FID); temperature parameters: column temperature 190°C, FID temperature 250°C, temperature of

opening for receiving samples 250°C; carrier gas: high-purity nitrogen, 50 ml/min flow rate; fuel: high-purity hydrogen.

5. Data obtained
See attached table.

Findings and Discussion

(1) Characteristics of fatty acid composition in the muscles of 5 kinds of freshwater fish

1. From the results obtained as shown in the table, it can be seen that of the fats found in the muscles of five kinds of freshwater fish, the C16, C18, C20 and C22 series of unsaturated fatty acids make up about 74.2-81.6% of the total amount of fatty acids, and there are as many as six with double bonds. The saturated fatty acids are mostly in the C14, C16 and C18 series, but they also contain a small amount of the odd-number carbon C17:0. Saturated fatty acids make up 18.1-25.2% of the total quantity of fatty acids. Of these, C16:0 occurs in the greatest amount.

2. Under our testing conditions, we found a total of 18 kinds of fats in the 5 freshwater fish, including 4 kinds of saturated fatty acids, 4 kinds of monoenic acids and over 10 kinds of polyenic acids.

3. Of the fats found in the dorsal muscles of the grass carp, C18:3ω_3 occurred in the greatest quantity, making up 32.2% of the total. Of the fats found in the dorsal muscles of the round-headed bream, C18:1 occurred in the largest amount. This was 32.2% in the male fish and 42% in the female. Of the fats found in the dorsal muscles of the variegated carp, C18:1 also occurred in the largest amount, making up 21.5%. C18:1 also occurred in the greatest quantity in the dorsal muscles of the carp. This was 21.4% for the female fish. As for the silver carp, C22:6ω_3 occurred in greatest quantity among the fats found in the dorsal muscles, making up 15.8% of the total.

4. Of the highly unsaturated fatty acids, C20:5ω_3 (EPA) and C22:6ω_3 (DHA) are the ones that most people are interested in. They are important components of the fats found in marine fish and are active substances for the treatment of cardiovascular diseases in humans. Eating more marine fish can help to prevent cardiovascular diseases. From the findings of this test, it can be seen that the fats

in the muscles of the silver carp, variegated carp, carp, grass carp and round-headed bream also contain large amounts of EPA and DHA. DHA, in particular, makes up 4.4-15.8% of the total fat content. This shows that although the amount of EPA and DHA in the bodies of freshwater fish is not as high as in marine fish, it should not be simply discounted. Our findings differ from those of CHEN Shaolian (1983) with regard to fatty acid composition in the muscles of the silver carp and variegated carp. We believe this is because the samples were treated differently before collection. We used the chloroform - methyl alcohol method to extract the fat directly from the fresh fish samples at room temperature. The double bonds in C20:5ω_3 and C22:6ω_3 rarely suffered damage. Mr CHEN Shaolian, however, dried the fish samples in a thermostatic chamber at 100-105°C. This could have damaged the double bonds in C20:5ω_3 and C22:6ω_3. Comparatively speaking, we think the findings of our test are more in line with the actual circumstances.

5. The fats in the muscles of the mature fish of the five kinds of carp contain large amounts of linoleic acid C18:2, linolenic acid C18:3 and arachidonic acid C20:4. These are fatty acids essential to the human body. If these fatty acids can make up as much as 48.8% of the fat in the grass carp's muscles, they will have a very high nutritional value compared with livestock animals.

(2) The nutritional value and use of internal organs of freshwater fish

The fatty acid composition of the muscles of freshwater fish is basically similar to that of their internal organs, but the amounts differ. The carp's testes and ovaries contain especially large amounts of C22:6ω_3. This is somewhat similar to the findings of H. Kusaka (1985) with regard to the testes and ovaries of the whitefish [*lit.*, white salmon]. Its testes contain 17% C22:6ω_3 while the ovaries contain 16%. In the carp, the figures are 15.7% for the testes and 16.1% for the ovaries. The liver and pancreas of the silver carp contain large amounts of C22:6ω_3, making up 21.5% of the total. The C22:6ω_3 in the liver and pancreas of the variegated carp and grass carp is as high as 8%. The ω_3 content of the internal organs of the grass carp and silver carp is rather high, over 31%. It has already been discovered that highly unsaturated fatty acids with the long carbon chain ω_3, particularly DHA and EPA, are especially effective in the treatment of cardiovascular diseases. Hence, the

fact that the internal organs of such seldom eaten freshwater fish contain such large amounts of useful fatty acids cannot be ignored. On the basis of this, it can be said that there is much room for development in the multiple use of fats in the internal organs of freshwater fish.

附 表 中国5种淡水鱼鱼体各部位的脂肪酸组成(%)

Attached table Fatty acid composition(%) of some parts for five freshwater fishes in China

1 鱼种		2 草鱼				3 鲢				4 鲑			5 鲫			6 团头鲂					
16 脂肪酸组成(%) \ 7 样品		8 背肌	9 腹肌	10 肠	11 肝脏	12 雄鱼背肌	13 雌鱼背肌	14 精巢	15 卵巢	8 背肌	10 肠	11 肝脏	8 背肌	10 肠	11 肝脏	12 雄鱼背肌	13 雌鱼背肌	22 雄鱼肠	23 雌鱼肠	14 精巢	15 卵巢
17 饱和脂肪酸	C14:0	1.1	1.1	1.2	1.3	1.2	1.6	0.5	1.4	5.1	7.7	8.4	3.6	4.4	3.0	1.1	1.3	1.6	1.7	1.5	1.3
	C16:0	16.7	16.0	13.4	17.5	14.3	16.5	16.5	20.4	15.5	13.4	17.5	15.5	14.7	19.1	17.5	16.4	15.2	13.5	18.0	20.5
	C17:0	—	0.2	0.2	0.2	0.6	0.4	0.4	0.6	1.9	2.8	1.8	0.5	0.3	0.6	—	0.2	0.2	0.2	—	0.2
	C18:0	1.2	0.8	—	1.5	3.5	3.2	3.8	4.4	2.7	1.8	4.1	2.5	1.1	1.1	1.5	0.4	—	—	1.0	1.6
	18 合 计	19.0	18.1	14.8	20.5	19.6	21.7	21.2	26.8	25.2	25.7	26.8	22.1	20.5	23.8	20.1	18.3	17.0	14.4	20.5	23.6
19 不饱和脂肪酸 20 一烯酸	$C16:1\omega_7$	3.3	3.6	3.2	4.3	2.5	3.0	1.9	3.8	5.1	3.0	4.4	7.1	7.6	7.5	2.0	3.3	3.2	2.7	4.4	1.7
	$C18:1\omega_7\omega_9$	17.5	18.2	22.6	23.7	12.5	21.4	15.6	18.0	10.0	10.1	8.0	21.5	21.9	41.0	32.2	42.0	53.6	46.5	46.4	30.7
	$C20:1\omega_9$	0.3	0.3	0.4	0.8	5.0	5.4	2.0	1.3	5.3	3.2	3.0	5.1	6.0	4.4	3.0	4.8	4.5	6.2	3.7	3.1
	$C22:1\omega_9\omega_{11}$	1.2	1.3	1.4	1.4	3.0	0.7	—	—	2.6	3.2	2.7	2.8	3.4	2.0	4.0	6.6	5.2	9.2	4.0	1.4
	合 计	22.3	23.5	27.6	30.2	23.0	35.5	19.5	28.1	23.0	20.5	18.1	36.5	38.9	54.9	41.2	56.7	66.5	64.6	58.5	36.9
21 多烯酸	$C18:2\omega_6$	13.3	13.6	13.3	8.5	14.4	8.3	5.4	2.5	4.2	5.2	2.8	3.2	3.4	1.1	21.4	12.4	10.8	13.8	11.1	10.8
	$C18:3\omega_3$	32.2	34.6	36.6	22.1	1.3	1.0	0.4	—	6.9	11.5	4.7	8.7	10.8	3.1	3.4	3.5	3.7	4.1	3.4	2.1
	$C20:2\omega_6$(?)	0.5	0.5	0.5	0.7	1.1	1.5	0.8	0.7	0.3	0.6	0.6	0.9	1.1	0.9	0.7	0.8	0.1	0.5	0.5	0.6
	$C20:3\omega_6$	0.4	0.3	0.3	0.3	0.5	—	—	—	0.1	0.2	—	0.2	0.2	0.2	1.4	0.2	0.3	0.4	0.5	0.8
	$C20:4\omega_6$	3.3	2.9	2.7	4.2	17.0	12.8	19.4	14.2	5.0	3.1	6.0	4.4	3.6	2.9	4.3	2.5	0.5	0.6	1.6	8.2
	$C20:5\omega_3$	1.7	1.3	0.8	2.0	1.9	4.1	2.3	2.9	11.9	9.6	9.7	3.2	7.6	1.5	—	—	—	—	—	0.2
	$C22:4\omega_6$	0.4	0.4	0.3	0.9	2.6	2.0	5.0	3.0	0.6	0.8	2.1	1.1	1.2	0.8	0.6	0.4	0.1	0.2	0.4	1.6
	$C22:5\omega_6$	0.3	0.2	0.2	0.3	4.1	2.6	5.1	3.1	4.4	2.8	3.8	2.6	2.3	1.6	1.8	0.5	—	—	0.5	3.3
	$C22:5\omega_3$	1.5	1.3	0.9	1.2	2.4	2.1	1.9	1.8	2.0	1.6	3.4	2.0	1.8	0.9	0.4	0.4	0.1	0.2	—	0.8
	$C22:6\omega_3$	4.4	3.2	1.5	8.7	10.7	6.4	15.7	16.1	15.8	8.6	21.5	9.1	7.0	7.7	4.4	4.2	0.4	0.7	2.7	10.7
	18 合 计	58.0	58.0	57.1	48.9	56.0	40.8	56.0	44.3	51.2	44.0	54.6	40.4	39.0	20.8	38.4	24.9	16.0	20.5	21.0	39.0
	$\Sigma\omega_6$	18.2	17.6	17.3	14.9	39.7	27.2	35.7	23.5	14.6	12.7	15.3	12.4	11.8	7.6	30.2	16.8	11.8	15.5	14.9	25.3
	$\Sigma\omega_3$	39.8	40.4	39.8	34.0	16.3	13.6	20.3	20.8	36.6	31.3	39.3	28.0	27.2	13.2	8.2	8.1	4.2	5.0	6.1	13.7

Key to attached table:

1. Type of fish; 2. grass carp; 3. carp; 4. silver carp; 5. variegated carp; 6. round-headed bream; 7. sample; 8. dorsal muscles; 9. ventral muscles; 10. intestines; 11. liver and pancreas; 12. dorsal muscles of male fish; 13. dorsal muscles of female fish; 14. testes; 15. ovaries; 16. fatty acid composition (%); 17. saturated fatty acids; 18. total; 19. unsaturated fatty acids; 20. monoenic acids; 21. polyenic acids; 22. intestines of male fish; 23. intestines of female fish.

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